

## APPLICATION FOR PATENT

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Title: SATELLITE COMMUNICATION CARD

### FIELD AND BACKGROUND OF THE INVENTION

The present invention relates generally to satellite communications, and specifically to personal computer cards for use in satellite communication by radio frequency.

Very small aperture terminals (VSATs), comprising a small satellite dish or flat-plate antenna and appropriate modulating and demodulating hardware coupled to a dedicated computer, are known in the art as means for transferring data directly between locations via a satellite. VSATs are typically used for data exchange in point-to-multipoint data networks, such as automated teller machines (ATMs) and point-of-sale systems, and may also be used for other types data transfer such as direct video broadcasting (DVB).

Personal computer cards capable of receiving signals directly from satellite transmissions are also known in the art. For example, Gilat Satellite Networks Ltd., of Petah Tikva, Israel, produces a satellite receiver card called "SkySurfer" for installation in a personal computer. The card plugs into an industry-standard PCI bus, and is designed to receive direct video broadcasts using a coaxial cable connected to a dish antenna.

European patent application EP 0-734-140, whose disclosure is incorporated herein by reference, describes a portable satellite communications terminal based on a personal computer (PC) . An interface card is inserted into the PC, enabling the PC to

communicate with a satellite antenna through an external modulation/demodulation unit followed by an external radio frequency (RF) subsystem coupled to the antenna.

### SUMMARY OF THE INVENTION

5           It is an object of some aspects of the present invention to provide apparatus and methods for signal transmission from a personal computer.

          It is a further object of some aspects of the present invention to provide apparatus and methods for communication between a personal computer and a remote transmitter/receiver via satellite.

10           In preferred embodiments of the present invention, a plug-in communications card in a PC generates modulated radio frequency (RF) signals, which are conveyed via a coaxial cable to a power amplifier and an upconverter of an antenna system, for transmission via satellite. The card comprises a power connector which enables the power from a DC power supply to be conveyed via the card and the cable to the  
15 antenna system. Most preferably, the power supply is external to the computer. Thus signals and power to operate the upconverter and the power amplifier are transferred on the coaxial cable. The card plugs into an industry-standard bus in the PC, which controls the card's operation and conveys data to the card for transmission via the satellite.

20           The communications card comprises a frequency synthesizer for generating and transmitting the RF signals, preferably in a range between about 950 MHz and 3000 MHz or in any sub-range therein. The signals are conveyed via the coaxial cable to the upconverter and the power amplifier, which are preferably contained in the antenna system. The power level of the signals from the synthesizer is preferably of  
25 the order of 1 mW. The upconverter and power amplifier convert the RF signals to

higher frequencies and higher power, for transmission by an external dish or flat-plate antenna. Most preferably, the signals are modulated by a keying modulator, whose modulation scheme is user-selectable according to any standard modulation system, under control of the PC.

5 Before modulation, the signals are encoded by an encoder, also under the control of the PC, preferably using forward error correction (FEC) encoding or concatenated coding.

10 In some preferred embodiments of the present invention, the communications card comprises a fast interface bus connector, which enables the communications card to communicate directly with one or more other cards without needing to go through the PC bus. Preferably, a fast parallel data bus is used as the fast interface bus. Most preferably, the communications card uses the fast interface bus to communicate directly with a receiver card, having a corresponding fast interface bus connector, installed in the PC. When the receiver card is present, the fast interface bus may be  
15 used to transfer a synchronizing clock recovered from signals received by the receiver card, and transmissions from the communications card may be timed accordingly, as described, for example, in U.S. Patent Application 09/135,502, entitled, "Bi-Directional Communications Protocol," to Ben-Bassat et al., which is assigned to the assignee of the present patent application and incorporated herein by reference.

20 There is therefore provided, in accordance with a preferred embodiment of the present invention, a transmitter card for a personal computer, including:

a circuit board which plugs into the personal computer and which is coupled to exchange data via an industry-standard bus in the personal computer; and

25 radio frequency modulation circuitry on the circuit board, which receives the data and transmits radio frequency signals responsive thereto.

Preferably, the circuitry includes a frequency synthesizer generating the radio frequency signals.

Preferably, the frequency generated by the frequency synthesizer is set by a controller on the circuit board.

5           Alternatively, the frequency generated by the frequency synthesizer is set by conveying instructions via the computer bus.

Preferably, the card is coupled to an external antenna system, and includes a connector, through which a DC source external to the card powers the antenna system.

10           Preferably, the frequency modulation circuitry is coupled to convey the radio frequency signals to the antenna system via the connector.

Preferably, the modulation circuitry modulates the transmitted signals according to a predefined protocol in accordance with a command conveyed to the card via the industry-standard bus.

15           Alternatively, the modulation circuitry includes an encoder which encodes error correction into the transmitted signals according to a predefined protocol in accordance with a command conveyed to the card via the industry-standard bus.

Alternatively, the card includes an auxiliary connector through which the card is coupled to at least one other card located in the computer, such that signals pass between the cards without passing through the industry-standard bus.

20           Preferably, the signals are transmitted to a satellite.

There is further provided, in accordance with a preferred embodiment of the present invention, an RF communication card for a personal computer, including:

a circuit board which plugs into the personal computer and which is coupled to exchange data via an industry-standard bus in the personal computer;

RF circuitry on the circuit board, which receives the data and processes radio frequency signals responsive thereto; and

an auxiliary connector through which the card is coupled to at least one other card located in the computer, such that signals pass between the cards without passing  
5 through the industry-standard bus.

Preferably, the communication card conveys a synchronizing signal via the auxiliary connector.

There is further provided, in accordance with a preferred embodiment of the present invention, a satellite transceiver for a personal computer, including:

10 a transmitter card which plugs into the personal computer and which is coupled to exchange data via an industry-standard bus in the personal computer and which transmits radio frequency signals responsive to the received data;

a receiver card which plugs into the personal computer and which is coupled to transfer data via the industry-standard bus and which receives radio frequency  
15 signals and converts the received signals to data for transfer via the bus; and

an auxiliary bus directly connecting the transmitter card and the receiver card.

Preferably, the transmitter card and the receiver card include respective connectors coupling the cards to the auxiliary bus.

There is further provided, in accordance with a preferred embodiment of the present invention, a method for transmitting a radio frequency signal directly from a  
20 personal computer, including:

mounting a transmitter card in the personal computer;

conveying data to the card via an industry-standard computer bus in the personal computer; and

25 transmitting the radio frequency signal from the card responsive to the data.

Preferably, conveying data to the card includes determining a frequency band of the signal.

Alternatively, the method includes:

mounting a power connector on the card; and

5 powering an antenna system external to the card via the power connector.

Preferably, transmitting the radio frequency signal includes modulating the signal in accordance with a modulation scheme determined responsive to a command conveyed via the bus.

10 Alternatively, transmitting the radio frequency signal includes encoding an error correction onto the signal in accordance with an encoding scheme determined responsive to a command conveyed via the bus.

Alternatively, the method includes connecting the transmitter card to at least one other card via an auxiliary connector, such that signals pass between the cards without passing through the industry-standard bus.

15 Preferably, transmitting the signal includes transmitting the signal to a satellite.

There is further provided, in accordance with a preferred embodiment of the present invention, a method for transmitting and receiving signals between a satellite and a personal computer including:

20 coupling a transmitter card to an industry-standard bus in the computer;

transmitting radio frequency signals from the transmitter card responsive to data from the bus;

coupling a receiver card to the industry-standard bus;

25 receiving radio frequency signals in the receiver card responsive to data from the bus; and

coupling the transmitter and receiver cards together directly via an auxiliary bus separate from the standard bus.

Preferably, receiving radio frequency signals includes conveying a synchronizing signal from the receiver card to the transmitter card via the auxiliary  
 5 bus.

The present invention will be more fully understood from the following detailed description of the preferred embodiments thereof, taken together with the drawings in which:

## 10 BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic block diagram of a communications terminal coupled to an antenna system, in accordance with a preferred embodiment of the invention;

FIG. 2 is a schematic block diagram of a personal computer RF transmission card, in accordance with a preferred embodiment of the present invention;

15 FIG. 3 is a schematic block diagram of a personal computer RF transmission card coupled to a PC receiver card, in accordance with a preferred embodiment of the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

20 Reference is now made to Figure 1, which is a schematic block diagram of a communications terminal 10 coupled to an antenna system 70, in accordance with a preferred embodiment of the present invention. In terminal 10 a transmitter card 25 or 60 is installed in a vacant slot of an industry-standard bus 45, such as a PCI bus, comprising an address bus 46, a data/control signal bus 48, and a power bus 50, as  
 25 well as additional lines, of a personal computer 11. The busses of the computer are in

communication with corresponding busses of the card, and the output of the card is fed to antenna system 70. The operation of transmitter cards 25 and 60 is described in detail hereinbelow.

Preferably, computer 11 comprises the following standard components: a video display unit (VDU) 13, a user interface device 15 comprising a mouse and/or a keyboard, a central processing unit (CPU) 19 such as an Intel Pentium processor, a memory 21 comprising volatile (generally RAM) memory and non-volatile memory, such as a hard disk, and a power supply 17. Power supply 17 powers the above-mentioned standard components and the transmitter card. Preferably, personal computer 11 also comprises a receiver card 54, receiving its input from antenna system 70. Receiver card 54 is installed in a vacant slot of computer 11 and is connected thereby to bus 45.

Preferably, antenna system 70 comprises the following industry-standard components: a dish or flat plate antenna 23, an orthomode transducer 27, a low noise block 29, an upconverter 72, and a power amplifier 12. Transducer 27 directs signals received by antenna 23 to low noise block 29, wherein the received signals are amplified and downconverted to a lower frequency, and are then transferred to receiver card 54. Upconverter 72 converts transmitted signals from transmitter card 25 or 60 to a higher frequency range, typically a range in the Ku band, and the converted signals are then amplified in power amplifier 12. The converted signals are transferred via transducer 27 for transmission by antenna 23. Most preferably, power for upconverter 72 and amplifier 12 is supplied from a power supply 52 via transmitter card 25 or 60, as described below.

As will be seen below, transmitter cards 25 and 60 are similar. The main difference between transmitter cards 25 and 60 is that transmitter card 25



communicates with receiver card 54 exclusively via bus 45, whereas transmitter card 60 also communicates with receiver card 54 via a fast interface bus connector, described below, that enables the exchange of data between transmitter card 60 and receiver card 54 without the delays associated with bus 45.

Figure 2 is a schematic block diagram of transmitter card 25, in accordance with a preferred embodiment of the present invention. Preferably, all active components of card 25 are powered from power bus 50. A dedicated programmable main controller 26 controls the functioning of card 25. Most preferably, controller 26 is a high performance integrated communications controller, such as a QUICC 68360 produced by Motorola Inc., of Phoenix, Arizona. Controller 26 is provided with a memory 35 for data storage. Controller 26 communicates with busses 46, 48, and 50 via a glue logic device 33 and a bus interface device 28, such as a PLX9080, produced by PLX Technology Inc., of Sunnyvale, California. Controller 26 and other components on card 25 communicate with and are controlled by CPU 19 of personal computer 11, via busses 46 and 48.

Modulation circuitry 37 comprises frequency synthesizer 14 and associated circuits providing a baseband-modulated input thereto, as described further hereinbelow. Synthesizer 14 generates and transmits an RF signal, preferably in the range 950 MHz - 3000 MHz, or in any sub-range therein. Most preferably, synthesizer 14 is in a well-shielded and grounded enclosure, in order to substantially reduce noise transfer from the computer to the RF signal, and vice versa, as is known in the art. Preferably, synthesizer 14 is capable of supplying of the order of 1 mW of RF signal power into a connector 36. Most preferably, connector 36 comprises a 75 ohm impedance F-type connector which in turn supplies the signal via a suitable coaxial cable to antenna system 70.

To generate on the order of 1 watt of RF power, which is the power typically required for transmission of signals via satellite, system 70 generally requires on the order of 50 watts of DC power at 24 VDC. Preferably, the power is supplied by a DC power supply 52, external to the card and to the computer, the power supply receiving  
5 its power directly from an AC line source 54, preferably operating in the 100-240 VAC range. The DC power is fed to antenna system 70 via a suitable power connector 34 on card 25 and via connector 36.

Synthesizer 14 generates a specific radio frequency for a chosen channel of communication, for example 1000 MHz, according to commands received from  
10 controller 26. The radio frequency is modulated using baseband signal levels from a digital-analog converter 16, so that the modulated signal output from the synthesizer is compatible with an industry-standard protocol. Preferably, converter 16 also comprises a low-pass baseband filter to smooth the signals produced during the conversion.

15 The baseband signals provided to converter 16 are generated by a keying modulator 40 and a forward error correction (FEC) encoder 42, whose respective functions are described in more detail hereinbelow. Most preferably, the functions of keying modulator 40 and encoder 42 are realized in a single field programmable gate array (FPGA) 20, such as a FLEX6000 produced by Altera Corporation of San Jose,  
20 California. FPGA 20 is programmed by main controller 26, or alternatively from PC bus 46 and/or PC bus 48, in accordance with instructions stored in memory 21 (Figure 1). Alternatively, two or more field-programmable devices may be used to implement the modulator and encoder, and/or factory-programmed or hard-wired logic may be used for this purpose. Further alternatively, one or more application

specific integrated circuits (ASICs) may be used to implement the modulator and encoder.

Keying modulator 40 supplies modulation signals in a standard format, such as one of the phase shift keying (PSK) formats known in the art, for example MSK, BPSK, DPSK, QPSK, or OQPSK. The format may be chosen according to whatever protocol is required by a receiving station, such as a VSAT hub, that is to receive the signals from card 25, and is loaded into FPGA 20 as described above. It will be understood that where the format needs to be changed, e.g., for transmission to a different receiving station, FPGA 20 may be reprogrammed by the PC, preferably by loading a suitable program into FPGA 20 from memory 21. The reprogramming may be performed automatically according to a communications channel that is chosen, or may be performed via user interface 15 (Figure 1).

The data input to FPGA 20 is derived from the information to be transmitted, and is received by FPGA 20 from controller 26. For example, the data may comprise IP packets transmitted on any suitable bus known in the art.

Encoder 42 generates an optional forward error correction (FEC) signal for encoding onto the transmitted signal, by one of the standard methods known in the art such as Viterbi, concatenated, Turbo, or Reed-Solomon coding. Typically, the FEC encoding adds some redundant information to the transmitted signal, for the purpose of improving signal recovery at the receiver. The method chosen is dependent on the requirements of the receiving station, and is programmable into FPGA 20 as described above.

Reference is now made to Figure 3, which is a schematic block diagram of a transmission card 60, in accordance with a preferred embodiment of the present invention. Apart from the differences described below, card 60 is generally similar to

card 25 (Figure 2), and elements indicated by the same reference numerals in both card 25 and card 60 are generally identical in construction and operation. In addition to the elements of card 25, card 60 comprises an auxiliary connector, to wit, a fast interface bus connector 41, which is coupled to transfer signals to and from controller 26 via a receiver interface 62 and a first-in first-out (FIFO) buffer 31. Preferably, interface 62 is a functional block contained in FPGA 20. Connector 41 enables signals to be sent to and from other cards in the personal computer having similar fast interface bus connectors, without the delay and jitter introduced by standard PC busses.

Most preferably, connector 41 is connected by a cable 39 or mating connector to a similar connector 52 on receiver card 54 installed in the PC and is used to route data and synchronize the operation of the transmitter and receiver cards, for example, as described in the abovementioned U.S. patent application 09/135,502. Receiver card 54 comprises receiver circuitry 56, described in detail hereinbelow, which communicates directly with connector 41, and also communicates with busses 46, 48, and 50. Preferably, when the receiver and transmitter cards are communicating with a remote receiver/transmitter, such as a VSAT hub, using a slotted communications protocol, the receiver card transfers data to the transmitter card via connector 41. Controller 26 recovers a synchronizing pulse from the data, and uses the synchronizing pulse to time the transmissions of card 60 according to the protocol being used.

Receiver circuitry 56 most preferably comprises a tuner 51, an ASIC-based receiver 53, and an MPEG2 demultiplexer and decoder device 59. Tuner 51 receives incoming signals, typically digital video broadcast (DVB) signals, from Low Noise Block 29 of antenna system 70 (Fig. 1) and divides the signals to I and Q components,

as is known in the art. ASIC-based receiver 53 demodulates and converts the I and Q signals to digital data, and transfers the data to device 59. Most preferably, the data from ASIC-based receiver 53 is also transferred to connector 52 and from there to card 60, as described hereinabove. Decoder 59 utilizes a RAM 57 to store interim data used in its operation. Tuner 51, ASIC-based receiver 53, and decoder 59 communicate with bus 45 via a bus interface 55.

It will be appreciated that while the preferred embodiments described above refer specifically to satellite transmission, the transmitter card may be used to generate RF signals for terrestrial transmission, as well. It will thus be appreciated that the preferred embodiments are cited herein by way of example, and the full scope of the invention is limited only by the claims.